**3GPP TSG-RAN WG2#129 R2-2XXXXXX**

**Athens, Greece, 17 – 21 February 2025**

**Agenda item:** 8.1.2.3

**Source:** Ericsson

**Title:** Summary of LCM Procedure for Positioning Case1 (Ericsson)

**Document for:**  Discussion, Agreement

# Introduction

This document is the report of the following email discussion:

* [POST128][026][AIML] LCM Procedure for Positioning Case1 (Ericsson)

 Intended outcome:

• Discuss the FFS from the existing RAN2 Agreements

* Attempt to resolve the FFS which does not need RAN1 input
* Identify questions to ask to RAN1 for resolving FFS waiting on RAN1 progress

• Collect general guidelines on the criteria for deciding whether to enhance legacy method(s) or introduce new method

 Deadline: Phase 1: January 17th, 2025

The agreements for Positioning Case1 has been listed below, and the FFS are highlighted.

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| **RAN2#128****Agreements** 1 For POS Case 1, RAN2 confirm that the existing unsolicited UE capability report mechanism in LPP can support UE to report the applicable functionality in both “proactive” and “reactive” as a baseline.- Proactive case: When the applicability change, UE can send an unsolicited LPP ProvideCapabilities message to LMF .- Reactive case: If the applicability changes based on the configuration in LPP ProvideAssistanceData message in step 3, UE can send an unsolicited LPP ProvideCapabilities message to LMF. Configuration details are FFS 2 As a baseline, If the AIML based positioning method becomes non-applicable when LMF requests UE location estimation, UE cannot perform the AIML based positioning, and reply with LPP Providelocationinformation message with error cause. FFS if other fallback options are considered**RAN2#127bis****Agreements:**1: The following procedures for LCM for UE sided model for AI positioning case 1 is the baseline:Step 1: LMF may request the UE to report the supported functionalities at the UE side by *LPP request capabilities* message.Step 2: UE sends *LPP provide capabilities* message to LMF with the supported functionalities at the UE side.Step 3: LMF sends the *LPP provide assistance data* message (which may contain network side additional condition).Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message.Step 5: The LMF requests the inferred location information using the *LPP request location information* message.Step 6: UE reports the inferred location using *LPP provide location information* message.2: Whether the inference configuration is provided in step 3 or/and step 5 is FFS (to be revised based on RAN1 progress).3: Whether network side additional condition is needed and what it contains is FFS (to be revised based on RAN1 progress).4: FFS whether LMF controls the UE sending unsolicited LPP provide capabilities (i.e. whether step4 is sent reactively or proactively). FFS the signalling details. 5: RAN2 will decide whether AI positioning will be a new method after further details from RAN1 are received. **RAN2#126****Agreements:**1 The LPP Capability Transfer procedures (RequestCapabilities/ProvideCapabilities messages) are used to indicate supported AI/ML positioning capabilities. FFS how to handle dynamic capabilities, depending on further RAN1 progress and understanding of the functionality. 2 wait for RAN1 for associate ID discussion3 At least for Case 1, existing LPP procedures related to Location Information Transfer (RequestLocationInformation/ ProvideLocationInformation messages) are used for providing the results of the UE sided model inference operation. FFS further details on signaling enhancements |

# Contact Information

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| --- | --- | --- |
| Company | Name | Email Address |
| Xiaomi | Xiaolong Li | lixiaolong1@xiaomi.com |
| Apple | Peng Cheng | Pcheng24@apple.com |
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# Discussion

## General guidelines/factors influencing the decision on AI/ML positioning as a new method or an existing method.

Below we try to collect company’s opinion on what should be the main basis for deciding whether to select a new method or update the existing legacy method. Example: If (most)/same assistance data from legacy positioning method is applicable to AI/ML based technique then reuse the existing one, else use a new method.

This would serve as a basis for RAN2 to swiftly decide when more information is received from RAN1.

Companies are invited to provide their opinion on the principles that govern the selection of new method or update of existing method.

**Question** 1**: What is the criteria for deciding if AI/ML positioning should be introduced as a new method or introduced as an enhancement to an existing method?**

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| **Company** | **Guidelines/factors** |
| Xiaomi | We think the legacy positioning methods are defined according to different the PRS measurement, for example, DL-RSTD for the DL-TDOA, UE Rx-Tx time difference and gNB Rx-Tx time difference for the multi-RTT and DL-PRS-RSRP for the DL-AoD.Therefore, if the new PRS measurements are needed for the AI based positioning, the AI positioning should be introduced as a new method. |
| Apple | We understand there are two criteria:1. Whether any new measurement, as Xiaomi mentioned
2. Whether any new assistance data

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Further, companies are invited to express whether their initial preference is to update a legacy method or to define a new method.

**Question** 2**: What is the (initial) preferred view; update of legacy or introduce new method?**

**Option A: Enhancement of legacy**

**Option B: Introduce new method.**

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| **Company** | **A/B** | **Remark (Optional)** |
| Xiaomi | B | Considering the new PRS measurement is needed for the AI positioning, we prefer to introduce a new method. |
| Apple | B  | According to RAN1#119 agreement, new assistance data different from legacy UE-based DL-TDOA may be introduced. Furthermore, considering forward compatibility, we tend to think a new positioning method is cleaner way.AgreementFor AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:* Alternative 1. Info #7 is provided implicitly via associated ID.
	+ Associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 2. Info #7 can be provided either implicitly or explicitly by LMF. Note: no UE capability is introduced on whether info #7 is provided implicitly or explicitly, and the UE can request info #7 to be provided explicitly or implicitly.
	+ If provided implicitly, associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 3. Info #7 is **not** be provided from LMF to UE.
	+ If info #7 is not provided, UE may assume info #7 is consistent between training and inference.
* Alternative 4. Info #7 is provided explicitly from LMF to UE.
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## FFS which does not need RAN1 input

### Signaling enhancement for UE reporting location using AI/ML

In RAN2#126, below was agreed

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| At least for Case 1, existing LPP procedures related to Location Information Transfer (RequestLocationInformation/ ProvideLocationInformation messages) are used for providing the results of the UE sided model inference operation. FFS further details on signaling enhancements |

For Case 1, UE only reports location result to LMF without measurements. If taken as a new method, then there is default signaling for RequestLocationInformation/ ProvideLocationInformation messages as part of the procedure of new method, while when taken as legacy method then indication of AI/ML should be added in RequestLocationInformation/ ProvideLocationInformation messages.

**Question** 3**: Regarding LPP procedures related to Location Information Transfer, do companies agree with the following?**

* **If a new method is introduced, no additional signaling enhancements are needed, i.e., there is a default procedure to request and provide location;**
* **If the legacy method is reused, an AI/ML indication should be added in the request/provide location information.**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Agree with comment  | If the legacy method is reused, an AI/ML indication in the LPP request location information is enough, in other words, there is no need to add an AI/ML indication in the LPP provide location information. |
| Apple | Agree 1st bullet, 2nd bullet is postponed to stage 3 discussion | We agree 1st bullet. 2nd bullet is detailed stage 3 signaling design, which is not essential. We are not sure why rushing to make this agreement at this stage.  |
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### Fallback Configuration

In RAN2#128, it was agreed:

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| If the AIML based positioning method becomes non-applicable when LMF requests UE location estimation, UE cannot perform the AIML based positioning, and reply with LPP ProvideLocationInformation message with error cause. FFS if other fallback options are considered:  |

When LMF requests UE location estimation, if for any reason UE cannot perform the AIML based positioning, the question that arises is that whether there should be a fallback option apart from the error reporting (e.g.: fallback to legacy method).

**Question** 4**: Regarding fallback option, companies are requested to provide their view on whether they agree/disagree to have any other fallback configurations?**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Agree | For the periodic reporting, the requested functionality may not be available due to the time gap between the LPP request location information message and the LPP provide location information message, so the fallback configuration is necessary and the fallback configuration could reduce the positioning latency. Moreover, if the legacy positioning method is reused for the AI/ML positioning, the existing signaling could support the fallback configuration. |
| Apple | Disagree  | We think it is sufficient to rely on agreed UE reporting error code: 1. With UE reporting error code, LMF can already take corresponding reaction (e.g. configure non-AI/ML positioning) as legacy. Thus, fallback configuration is an optimization.
2. If NW provides fallback configuration, it implies that NW needs to simultaneously provide at least two sets of radio resource and assistance data normal operation and fallback operation (e.g. non-AI positioning and AI based positioning). It is radio resource consuming for NW and a new requirement for UE, but its benefit is not clear (maybe just saving latency of one LPP message?). Rel-19 AI/ML positioning doesn’t requirement for latency reduction. So, we are not convinced its necessity.
3. On the issue of time gap raised by Xiaomi, we think that is the reason why we introduce applicable functionality reporting.
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If yes, companies are invited to provide view on when the fallback should be (pre)configured (e.g., in which step fallback config is configured (step 1 to 6 of agreements) or if it is configured only after getting a failure message from the UE).

**Question** 5**: Regarding fallback option, when should the fallback be configured?**

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| **Company** | **Remark (when is fallback configured)** |
| Xiaomi | We think the fallback can be configured in step 5.  |
| Apple | If fallback is supported (although we are negative), we think it should be configured in step 3, which provides UE sufficient time to prepare the fallback operation. If it is provided in step 5, why not just rely on LMF reconfiguration?  |
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Further companies are invited to provide their view on what should be the fallback configuration? Should it be a particular positioning method or any legacy positioning method or simply an abort of procedure?

**Question** 6**: Regarding fallback option, what should the fallback configuration be?**

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| **Company** | **Remark (what should be the fallback configuration)** |
| Xiaomi | We think the DL-TDOA and DL-AoD can be considered for the fallback configuration.For example, LMF configures the UE to use DL-TDoA or DL-AoD related PRS measurement to acquire its location.  |
| Apple | If fallback is supported (although we are negative), we prefer to make it simple, i.e. an abort of procedure. |
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Similar to fallback, the UE may also switch from using non-AI/ML to AI/ML, e.g., UE is inapplicable for AI/ML Positioning when LMF sends RequestLocationInformation msg and later UE becomes applicable for AI/ML Positioning to be used. This would be applicable mainly for periodic positioning if there are several localizations needed over a period of time, and AI/ML Positioning is more favorable in the scenario, e.g., in NLoS condition. That is when the UE can perform both AI/ML and non-AI/ML, but initially UE reported that the applicability condition is not met but later it identifies the applicability conditions are met. Hence, should there be a switching option from non-AI/ML to AI/ML?

**Question** 7**: Do companies view a need of switching options that is to change from non-AI/ML to AI/ML, similar to fallback?**

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| **Company** | **Remark (Preference on Switching Configuration from non-AI/ML to AI/ML)** |
| Xiaomi | We don’t support that UE switches the positioning method autonomously with the functionality applicability change since the positioning method should be controlled by the LMF, and he LMF could switch the positioning method to AI/ML positioning method according to the functionality reporting from UE. |
| Apple | Not support. We can rely on LMF reconfiguration, instead of introducing more UE complexity for unclear benefit.  |
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### Error Causes

*NR-AI-ML-TargetDeviceErrorCauses*

The IE *NR-AI-ML-TargetDeviceErrorCauses* is used by the target device to provide NR AI/ML positioning error reasons to the location server.

-- ASN1START

NR-AI-ML-TargetDeviceErrorCauses-r19 ::= SEQUENCE {

 cause-r19 ENUMERATED { assistanceDataInconsistentBetweenTrainingAndInference,

 thereWereNotEnoughSignalsReceivedForUeBasedAI-ML,

 resourceOrProcessingCapacityIssueForAIML,

 battery-low,

 ...

 },

 ...

}

-- ASN1STOP

**Question** 8**: For Case 1 error causes, do companies agree with the above error causes? Please add if anything is missing.**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi |  | For the periodic reporting, the requested functionality may not be available due to the time gap between the LPP request location information message and the LPP provide location information message, so we suggest to add to cause *functionalityNotAvailable*.  |
| Apple | Postpone to stage 3 discussion  | We are not why rushing to have detailed stage 3 signaling design, even before RAN1 design is not clear (e.g. what does “assistanceDataInconsistentBetweenTrainingAndInference” mean before RAN1 don’t conclude on assistance data design).  |
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### Inference configuration

In RAN2#127bis, there is an FFS along the agreements

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| 2: Whether the inference configuration is provided in step 3 or/and step 5 is FFS (to be revised based on RAN1 progress). |

In Step 3, the assistance data is sent from LMF to UE, and at this stage LMF has no information about whether UE meets applicability condition for using AI/ML model or not. In this regard, the PRS configuration in Step 3 is assistance which may be used for inference, but it is up to the UE to decide suitable PRS config that is applicable for inference. LMF on the other hand only requests whether UE should perform AI/ML inference or not in Step 5 after receiving the applicability condition from the UE in Step 4 and thus the request location information (Step 5) is used for inference configurations.

**Question** 9**: Do companies agree that Step 5 is the step where an inference configuration is provided?**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Agree |  |
| Apple | Agree |  |
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### On LMF control for Unsolicited Applicability Reporting

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| RAN1 128 Agreement1 For POS Case 1, RAN2 confirm that the existing unsolicited UE capability report mechanism in LPP can support UE to report the applicable functionality in both “proactive” and “reactive” as a baseline.- Proactive case: When the applicability change, UE can send an unsolicited LPP ProvideCapabilities message to LMF .- Reactive case: If the applicability changes based on the configuration in LPP ProvideAssistanceData message in step 3, UE can send an unsolicited LPP ProvideCapabilities message to LMF. Configuration details are FFS  |

It has been agreed that existing unsolicited UE capability report mechanism in LPP can support UE to report the applicable functionality in both “proactive” and “reactive” as a baseline. However, a question that remains (FFS) is whether there is a need for LMF to control on sending these unsolicited messages.

We need to note here that there are two attributes:

1. Capability: AI/ML Functionality for Positioning
2. Applicable functionality.

The applicability reporting is considered a dynamic attribute which is associated with AI/ML Positioning functionality. In legacy, this dynamic capability can be considered similar to remoteUE-Indication (e.g. as mentioned in discussion paper [R2-2410475]). This has been used for the case where UE reports its coverage state. That is if the UE is out of coverage and connected via a relay UE. This is needed for the LMF to select the right positioning method. This attribute is controlled by LMF.

***remoteUE-IndicationReq***

This field, if present, indicates that the target device is requested to indicate if it operates as a L2 U2N Remote UE.

For AI/ML case, it should be up to LMF to decide whether to configure AI/ML based inference or use legacy mechanism for obtaining the UE location. Hence, LMF would require assistance information from UE if the reported capability on AI/ML functionality for positioning meets UE side and NW side additional conditions to decide if LMF should pursue AI/ML or non-AI/ML (legacy technique) and in such case, it should be up to LMF to configure the needed relevant assistance information from UE. That is, whether step 4 is needed or not should be configured by LMF. There can be cases where LMF may have already decided not to pursue AI/ML based method, (example QoS of another UE in the same cell portion using AI/ML was not met).

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|  Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message. 4: FFS whether LMF controls the UE sending unsolicited LPP provide capabilities (i.e. whether step4 is sent reactively or proactively). FFS the signalling details.  |

**Question** 10**: Do companies agree with above that LMF should provide configuration that would allow the UE to send unsolicited LPP to provide capabilities similar to remoteUE-Indication (e.g: aiml-ApplicabilityReq in RequestCapability)?**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Disagree | We think, anyway, this is a UE capability and there is no harm in reporting it to the LMF without LMF control.Moreover, if the LMF wants to use the AI/ML positioning method, it can use it directly according to the functionality applicability reporting. Otherwise, the LMF should request the UE to report the applicable functionality and then indicates the UE to use the AI/ML positioning method, which will lead to additional positioning latency.” |
| Apple | Disagree | As legacy LPP, the NW control is implicitly enforced in a LPP positioning session. Legacy LPP unsolicited information transfer procedure doesn’t need LMF control whether the UE can report.On the exceptional case of L2 U2N relay quoted by moderator, we think it is different from AI/ML based positioning. According to Rel-18 discussion the reason to introduce “***remoteUE-IndicationReq”*** is due to some special technique issue of L2 U2N relay rather than due to dynamic capability. For example: 1. Serving cell timing is not known by remote UE

Some positioning methods requires serving cell timing by target UE. The Relay UE knows the SFN timeline of its serving cell, but the Remote UE only sees the DFN timeline provided by the Relay UE.1. L1/L2 Uu signaling can’t be used by remote UE

There are some MAC-CE/DCI specified for positioning (e.g. AP/SP SRS activation/deactivation, Measurement Gap activation/deactivation). They can’t be used for the Remote UE because there is no L2 forwarding on L1/L2 siganling specified.Thus, the IE for remote UE status reporting is due to L2 relay special issue and system may not work if no such indication reported to LMF. However, for AI/ML based positioning, the applicable functionality reporting in step 4 falls into the legacy LPP unsolicited information transfer procedure. We fail to see any serious technique issue without explicit LMF configuration in AI based positioning. Thus, we think it is only an optimization, and prefer to keep the legacy LPP procedure.  |
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## Questions to ask to RAN1 for resolving FFS waiting on RAN1 progress

### Applicable functionality reporting

Do companies agree that RAN2 can provide below Agreements sequence flow (steps) and ask RAN1what would be the message content of step 4 (UE side additional condition).

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| **Agreements:**1: The following procedures for LCM for UE sided model for AI positioning case 1 is the baseline:Step 1: LMF may request the UE to report the supported functionalities at the UE side by *LPP request capabilities* message.Step 2: UE sends *LPP provide capabilities* message to LMF with the supported functionalities at the UE side.Step 3: LMF sends the *LPP provide assistance data* message (which may contain network side additional condition).Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message.Step 5: The LMF requests the inferred location information using the *LPP request location information* message.Step 6: UE reports the inferred location using *LPP provide location information* message.2: Whether the inference configuration is provided in step 3 or/and step 5 is FFS (to be revised based on RAN1 progress).3: Whether network side additional condition is needed and what it contains is FFS (to be revised based on RAN1 progress).4: FFS whether LMF controls the UE sending unsolicited LPP provide capabilities (i.e. whether step4 is sent reactively or proactively). FFS the signalling details. 5: RAN2 will decide whether AI positioning will be a new method after further details from RAN1 are received.  |

RAN2 would like to ask RAN1 if RAN1 has any opinion on whether there are any specific UE signaling as part of the applicable functionality report.

Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message.

**Question** 11**: Do companies agree to pose a question to RAN1 asking “RAN2 would like to ask RAN1 if there are any specific parameters as part of the applicable functionality report from the UE”?**

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| **Company** | **Yes/No** | **Remark** |
| Xiaomi | No | We think this is not necessary since we understand that RAN1 will work on FG for AI/ML positioning in the later meeting.  |
| Apple | No | RAN1 is already quite busy. We don’t think it is important question to bother RAN1.  |
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### Consistency between training and inference

To ensure consistency between training and inference, UE should receive assistance with NW side additional condition. According to the RAN1 progress listed so far, all assistance information from legacy UE-based DL-TDOA, other than info #7 have been agreed.

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| RAN1 AgreementFor AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:* Alternative 1. Info #7 is provided implicitly via associated ID.
	+ Associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 2. Info #7 can be provided either implicitly or explicitly by LMF. Note: no UE capability is introduced on whether info #7 is provided implicitly or explicitly, and the UE can request info #7 to be provided explicitly or implicitly.
	+ If provided implicitly, associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 3. Info #7 is **not** be provided from LMF to UE.
	+ If info #7 is not provided, UE may assume info #7 is consistent between training and inference.
* Alternative 4. Info #7 is provided explicitly from LMF to UE.

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| 7 | Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

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Several approaches to ensure consistency on the table:

* NW allocates associated ID
* UE’s on-demand request on NW side additional conditions

**Question** 12**: For Case 1, do companies agree to ask to RAN1 “what will be the approach to ensure the consistency”?**

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| **Company** | **Yes(ask question)/No (let RAN1 conclude)** | **Remark** |
| Xiaomi | No | Wait for the progress from RAN1.  |
| Apple | No | As quoted by moderator, RAN1 is discussing this issue. We see no reason to send LS to push RAN1 at this stage.  |
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**Question** 13**: Do companies see any other question that may be raised for NW side additional condition?**

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| **Company** | **Yes/No** | **Remark (Pls provide the question to be asked)** |
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### UE side additional condition

* Should a question be raised to RAN1, if there is any specific need for UE to report UE side additional condition? If question needs to be asked to RAN1, pls provide what it should be?
* Or if RAN2 understands that this is already covered by UE reporting applicable functionality.

**Question** 14 **Companies are requested to select one or multiple of the Options:**

**Option A: Need to send as LS to RAN1 for UE side additional condition**

**Option B\_ No need to send an LS to RAN1 for UE side additional condition**

**Option C: UE side additional condition is covered by 3.3.1 Applicable Functionality Reporting; and an LS can be sent depending upon 3.3.1 discussion.**

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| **Company** | **Option A/B/C** | **Remark (Pls provide the question to be asked)** |
| Xiaomi | Option C | In our understanding, there is no need to specify the UE side additional condition and UE only needs to the report the applicable functionality according to the network side additional condition, AI model and UE side additional condition.  |
| Apple | Option C with change or Option B | We have same view as Xiaomi that UE-side additional condition is already covered by UE reporting applicable functionality, and there is no need to specify the UE side additional condition. But as we comment on Section 3.3.1, we see no reason to send LS to RAN1 for these non-essential issues. Thus, we suggest below change on Option C:**Option C: UE side additional condition is covered by 3.3.1 Applicable Functionality Reporting~~; and an LS can be sent depending upon 3.3.1 discussion.~~** |
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### Other questions to ask RAN1

Companies are invited to input if there are other questions that should ask RAN1.

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| **Company** | **Remark (Pls provide the question to be asked)** |
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# Conclusion

The discussion above can be summarized in the form of the following proposals:

[TBF]

# Annex RAN1 agreements

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| **RAN1#116**AgreementFor Rel-19 AI/ML based positioning, the measurements for determining model input are based on the DL PRS and UL SRS defined in TS38.211.* Note: The use of SRS for MIMO resource is transparent to UE.

Agreement* For AI/ML based positioning case 3b, at least the following types of time domain channel measurements are supported for reporting:
1. timing information;
2. paired timing information and power information.

Agreement* For AI/ML based positioning case 2b, at least the following types of time domain channel measurements are supported for UE reporting to LMF:
1. timing information;
2. paired timing information and power information.

AgreementIn Rel-19 AI/ML based positioning, regarding the time domain channel measurements, RAN1 investigate the following alternatives:* + - * Alternative (a). Sample-based measurements, where the timing information is an integer multiple of sampling periods.
			* Alternative (b). Path-based measurements, where the timing information is according to the detected path timing and may not be an integer multiple of sampling periods.

The issues to be studied include, but not limited to, the following:* + - * Tradeoff of positioning accuracy and signaling overhead
			* Impact and necessary details of gNB/UE implementation to obtain the channel measurement values.
			* Whether the same Alternative(s) applies to all cases or not
			* Applicability and necessity of specifying the Alternative(s) to different cases
			* Note: different sub-cases may have different issues.

Note: In addition to timing information, the components for the channel measurement for model input may also include power and potentially phase. To provide the type of the channel measurement in their investigation.AgreementFor AI/ML assisted positioning Case 3a, at least LOS/NLOS indicator and/or timing information are supported for reporting. * If LOS/NLOS indicator is reported, the indicator can be reported as soft indicator or hard indicator as defined in 38.214.
* If timing information is reported, the timing information at least can be reported via UL RTOA or gNB Rx-Tx time difference as defined in 38.215.
* Note: details of the report are pending further discussion.

AgreementFor AI/ML assisted positioning Case 2a, at least LOS/NLOS indicator and/or timing information are supported for reporting. * If LOS/NLOS indicator is reported, the indicator can be reported as soft indicator or hard indicator as defined in 38.214.
* If timing information is reported, the timing information at least can be reported via DL RSTD or UE Rx-Tx time difference as defined in 38.215.
* Note: details of the report are pending further discussion.

AgreementFor LMF-side model, RAN1 studies whether/what assistance information and/or measurement report may be sent from UE/PRU, and/or gNB to LMF to assist at least for the performance monitoring.* RAN1 understands that it is out of RAN1 scope to define monitoring metric calculation and related model management decisions for LMF-side model.

AgreementFor AI/ML based positioning Case 3b, for gNB channel measurements reported to LMF, the timing information is represented relative to a reference time. * FFS: Whether any specification impact of the reference time used to represent the timing information. Details of the reference time

AgreementFor AI/ML based positioning for all use cases, RAN1 investigate the necessity and feasibility of using phase information (in addition to timing information and power information) for determining model input. The issues to study include:* Tradeoff of positioning accuracy and signaling overhead
* The impact of transmitter and receiver implementation
* Specification impact
* Other aspects are not precluded

Note: the phase information may be used in different ways, e.g., one phase value for the first path or first sample only; triplet of {timing information, power information, phase information} for CIR, etc.**RAN1#116bis**AgreementFor AI/ML based positioning Case 3b, for gNB channel measurements reported to LMF, the timing information is represented relative to the existing UL RTOA reference time T0+tSRS as defined in TS 38.215. FFS: whether it is applicable when Case 3b is used to support multi-RTT Conclusion* It is out of RAN1 scope to decide whether/how synthetic data (i.e., not direct physical data) and related entities are used in AI/ML based positioning. In RAN1 discussion, data (e.g., measurement data, label data) refer to physical data, not synthetic data.

Working AssumptionFor training data generation of AI/ML based positioning Case 1, the measurement and its related data (e.g., timestamp) are generated by PRU and/or Non-PRU UE.AgreementFor training data generation of AI/ML based positioning Case 3a and 3b, the measurement and its related data (e.g., timestamp) are generated by TRP/gNB.AgreementFor training data collection of AI/ML based positioning, the collected data sample can include the following components:Part A:* channel measurement
* quality indicator of channel measurement
* time stamp of channel measurement

Part B:* ground truth label (or its approximation)
* quality indicator of label
* time stamp of label

Note: “Part A” and “Part B” terminologies are only for RAN1 discussion purpose, and may not be used in specification. Note: contents in Part A and Part B may or may not be generated by different entities.Note: Part A and/or Part B, and their contents may or may not apply for each caseFFS: detailed definition of channel measurementWorking AssumptionFor training data generation of AI/ML based positioning Case 2a and 2b, the channel measurement and its related data (e.g., time stamp) are generated by PRU and/or non-PRU UE.Working AssumptionFor training data generation of AI/ML based positioning Case 1, the label and its related data (e.g., time stamp) can be generated by: * PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of the label and its related data is out of RAN1 scope.Working AssumptionFor training data generation of AI/ML based positioning Case 2a, the label and its related data (e.g., time stamp) can be generated by: * PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of the label and its related data is out of RAN1 scope.Working AssumptionFor training data generation of AI/ML based positioning Case 2b, the label and its related data (e.g., time stamp) can be generated by: * PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of label and its related data is out of RAN1 scope.Working AssumptionFor training data generation of AI/ML based positioning Case 3b, the label and its related data (e.g., time stamp) can be generated by:* PRU
* FFS: Non-PRU UE with estimated location
* LMF

Note: transfer of label and its related data is out of RAN1 scope.AgreementFor training data generation of AI/ML based positioning Case 3a, the label and its related data (e.g., time stamp) can be generated by at least:* LMF

Note: transfer of label and its related data is out of RAN1 scope. Note: whether other network entities can generate label for Case 3a is out of RAN1 scope. AgreementFor AI/ML positioning Case 3a, for model performance monitoring metric calculation in label-based model monitoring, study the feasibility of the following options. To provide information on how to generate information on ground truth label for each option.* Option A. NG-RAN node performs monitoring metric calculation for its own model.
* Option B. LMF performs monitoring metric calculation for the model located at the NG-RAN node.

Note: Final selection of Option A and Option B is out of RAN1 scope, but RAN1 can make recommendation about the option(s), and potential support of Option A and/or Option B is pending RAN3 confirmation.Note: Exact method to perform the monitoring metric calculation is up to implementationAgreementFor model performance monitoring of AI/ML positioning Case 1, for model performance monitoring metric calculation in label-based model monitoring, study the feasibility, benefits, and potential specification impact of the following options with regard to how to generate information on ground truth label: * Option A. The target UE side performs monitoring metric calculation.
	+ Option A-1. At least information on ground truth label of the target UE is generated by LMF and provided to the target UE.
		- In one example, target UE and/or gNB sends measurement (e.g., legacy measurement) to LMF so that LMF can derive the information on ground truth label.
	+ Option A-2. At least position calculation assistance data (e.g., existing information for UE-based positioning method) is provided from LMF to the target UE.
	+ Option A-3. Reuse Rel-18 assistance data transfer framework from LMF to the target UE, where the PRU measurement (e.g., legacy measurement) and the corresponding PRU location are sent via LMF to the target UE.
	+ Option A-4. PRU measurement (and the corresponding PRU location if not already known at the UE-side) are sent from PRU to the target UE side ~~(e.g., target UE, OTT server)~~.
		- Note: Option A-4 can be realized by implementation in a manner transparent to specification if the PRU sends information to the target UE side in a proprietary method.
* Option B. The LMF performs monitoring metric calculation.
	+ Option B-1. at least inference result (i.e., the model output corresponding to target UE’s channel measurement) of the target UE is sent by the target UE to LMF.
	+ Option B-2. PRU’s channel measurement is sent via LMF to the target UE, and the inference result (i.e., the model output corresponding to PRU’s channel measurement) is sent by the target UE to LMF.

Note: exact method to perform the monitoring metric calculation is up to implementation. Note: Other options are not precluded.**RAN1#117** Working AssumptionFor training data generation of AI/ML based positioning Case 3b, the label and its related data (e.g., time stamp) can be generated by:* PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of label and its related data is out of RAN1 scope.Note: It is assumed that user data privacy of non-PRU UE is preserved.Note: Previous related working assumption made in RAN1#116bis for training data generation of AI/ML based positioning Case 3b will not need to be confirmed.AgreementSample-based measurement is defined as:* The measurement is composed of Nt' samples of the estimated channel response in time domain. The timing information for the Nt' samples are reported with a timing granularity T, where T=2kxTc. k represents the timing reporting granularity factor. Tc is the basic time unit for NR.
	+ The corresponding measurement (e.g., power if reported) corresponds to the measurement for the reported Nt' samples.
* Nt' and k can be signalled
	+ FFS: the value range of Nt'; the value range of integer k for the timing granularity T.
* The timing information is defined relative to a reference time

Further discussion is expected on the determination of Nt' and k (including signaling) , and a rule to be introduced for selecting Nt' samples.Note: It doesn’t imply the definition of Sample-based measurement will be captured into the spec.AgreementPath-based measurement refers to the measurement in the existing specifications (up to Rel-18) including measurement reporting, with potential enhancements on the number of reported paths (if needed).**Agreement**For training data collection of AI/ML based positioning, if a training data sample contains both Part A and Part B, RAN1 assumes that Part A and Part B in one training data sample are: * for a same UE (PRU or Non-PRU UE), and
* for a same location associated with Part B.

Note: the association can be discussedAgreementDraft LS R1-2405577 is endorsed in principle by adding the latest agreements made in this meeting and adding “agreements” to “Note: the working assumptions above are based on RAN1 understanding for RAN work item (NR\_AIML\_air).”AgreementFinal LS R1-2405578 is endorsed.**RAN1#118**AgreementFor AI/ML positioning Case 3a, for performance monitoring metric calculation in label-based monitoring, from RAN1 perspective, Option A and Option B are feasible,* Option A. NG-RAN node performs monitoring metric calculation for its own model.
* Option B. LMF performs monitoring metric calculation for the model located at the NG-RAN node.

Note: Final selection of Option A and Option B is out of RAN1 scope. Potential support of Option A and/or Option B is pending RAN3 confirmation. Note: Exact method to perform monitoring metric calculation is up to implementation.Note: For Option A, RAN1 assumes that user data privacy needs to be preserved.ConclusionFor model performance monitoring of AI/ML positioning Case 1, for model performance monitoring metric calculation in label-based model monitoring,* Option A-4 can be realized by implementation in a manner transparent to specification specification if the PRU sends information to the target UE side in a proprietary method. No further discussion on Option A-4.

AgreementFor training data collection of AI/ML based positioning case 3b, for time stamp of channel measurement, * For channel measurement generated by TRP/gNB, existing IE “Time Stamp” in TS 38.455 can be reused from RAN1 perspective
* Note: Purpose, such as above “training data collection", will not necessarily be specified in RAN 1 specifications

AgreementFor training data collection of Case 1 and 2a, in terms of DL PRS configuration for collecting training data, RAN1 study the following options on assistance data, using legacy mechanisms as a starting point:Option A. (UE initiated) UE makes a request to LMF on the preferred DL PRS configuration for training data collection, e.g., on-demand PRS. LMF makes the decision on determining the DL PRS configuration for training data collection and provides the assistance data to the UE. Option B. (LMF initiated) LMF determines the DL PRS configuration for training data collection and provides the assistance data to the UE.Note: the UE can be a PRU and/or a Non-PRU UE.Note: as in existing specification, the DL PRS configurations in the assistance data from LMF to UE are based on DL PRS configuration coordinated between LMF and gNB.AgreementFor the definition of sample-based measurement, select Nt’ samples out of a list of Nt consecutive samples* The Nt samples have timing granularity T.
* FFS: the starting time of the list of Nt samples
* FFS: the value range of Nt

For the sample-based measurement (if accepted in Rel-19), * For measurement by TRP/gNB, the Nt’ selected samples are expected to be those with the highest power.
* Note: Choice of the maximum value of Nt, Nt’ should take into account the need to preserve proprietary implementation.

AgreementFor AI/ML positioning Case 2b and 3b, regarding the power information for determining the model input,* For downlink power measurement, use DL PRS-RSRPP defined in TS 38.215 as a starting point.
	+ For measurement report of DL PRS-RSRPP, use the existing measurement report mapping table for PRS-RSRPP in 38.133 as a starting point.
* For uplink power measurement, use UL SRS-RSRPP defined in TS 38.215 as a starting point.
	+ For measurement report of UL SRS-RSRPP, use the existing measurement report mapping table for SRS-RSRPP in 38.133 as a starting point.

ConclusionFrom RAN1 perspective, for Case 3a measurements, * The existing procedures can be reused in terms of SRS configuration.
	+ Note: parameter values for SRS configuration can be further discussed
* These measurements can be used for multiple aspects related to case 3a, e.g. training data collection, monitoring, or inference procedures.
* Note: Purpose, such as the training data collection, monitoring, or inference procedures mentioned above, will not necessarily be specified in RAN 1 specifications

AgreementFor Rel-19 AI/ML based positioning Case 3b, regarding sample-based measurement (if supported), from RAN1 perspective, * LMF can signal parameter values of Nt, Nt', k to gNB via NRPPa.

**RAN1#118bis**AgreementFor training data collection of AI/ML based positioning, the quality indicator of timing information in Part A when reported is:* When applicable, the existing IE for timing quality, i.e., NR-TimingQuality in 37.355 and IE “Timing Measurement Quality” in 38.455;
	+ FFS: details on how to associate quality indicator to timing information

ConclusionFor training data collection of Case 1, in terms of DL PRS configuration for collecting training data, both options are feasible by using legacy mechanisms:Option A. (UE initiated) UE makes a request to LMF on the preferred DL PRS configuration for training data collection, e.g., on-demand PRS. LMF makes the decision on determining the DL PRS configuration for training data collection and provides the assistance data to the UE. Option B. (LMF initiated) LMF determines the DL PRS configuration for training data collection and provides the assistance data to the UE.Note: the UE can be a PRU and/or a Non-PRU UE.Note: as in existing specification, the DL PRS configurations in the assistance data from LMF to UE are based on DL PRS configuration coordinated between LMF and gNB.AgreementFrom RAN1 perspective, for model inference of AI/ML positioning Case 3b, at least the following are mandatorily or optionally supported in a measurement report from gNB to LMF:* (Mandatory) Channel measurement;
* (Optional) Quality of the channel measurement;
	+ FFS: details of the quality
* (Mandatory) Time stamp of the channel measurement.

AgreementFrom RAN1 perspective, when timing information is reported for Rel-19 AI/ML positioning Case 3a, at least the following are mandatorily or optionally supported in a measurement report from gNB to LMF:* (Mandatory) timing information;
* (Optional) Quality of the timing information;
	+ Existing IE “Timing Measurement Quality” can be reused.
* (Mandatory) Time stamp.

FFS: LOS/NLOS indicator.Note: The final decision of “mandatory” or “optional” presence of each field is up to RAN3.AgreementFor AI/ML positioning Case 1, regarding the assistance data provided from LMF to UE, for ensuring consistency between training and inference, * for each of the existing assistance data IE of UE-based DL-TDOA and/or UE-based DL-AoD, study whether it should be: (a) explicitly indicated, (b) implicitly indicated and/or (c) other;
* Companies can provide inputs on further enhancements of existing assistance data, including new information
* Note: this does not mean that training and inference phases are mentioned in assistance data.

Table. Existing assistance data (supported up to Rel-18) that may be transferred from LMF to UE in UE-based DL-TDOA [1] or UE-based DL-AoD [2], as applicable.

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Information** | **UE-based DL-TdoA** | **UE-based DL-AoD** |
| 1 | Physical cell IDs (PCIs), global cell IDs (GCIs), ARFCN, and PRS IDs of candidate NR TRPs for measurement |  |  |
| 2 | Timing relative to the serving (reference) TRP of candidate NR TRPs |  |  |
| 3 | DL-PRS configuration of candidate NR TRPs |  |  |
| 4 | Indication of which DL-PRS Resource Sets across DL-PRS positioning frequency layers are linked for DL-PRS bandwidth aggregation |  |  |
| 5 | SSB information of the TRPs (the time/frequency occupancy of SSBs) |  |  |
| 6 | Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB |  |  |
| 7 | Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |  |  |
| 8 | Fine Timing relative to the serving (reference) TRP of candidate NR TRPs |  |  |
| 9 | PRS-only TP indication |  |  |
| 10 | The association information of DL-PRS resources with TRP Tx TEG ID |  |  |
| 11 | LOS/NLOS indicators |  |  |
| 12 | On-Demand DL-PRS-Configurations, possibly together with information on which configurations are available for DL-PRS bandwidth aggregation |  |  |
| 13 | Validity Area of the Assistance Data |  |  |
| 14 | PRU measurements together with the location information of the PRU |  |  |
| 15 | Data facilitating the integrity results determination of the calculated location |  |  |
| 16 | TRP beam/antenna information (including azimuth angle, zenith angle and relative power between PRS resources per angle per TRP) |  |  |
| 17 | Expected Angle Assistance information |  |  |
| 18 | PRS priority list |  |  |

[1] Table 8.12.2.1.0-1 in 38.305, Use equipment (UE) positioning in NG-RAN (Release 18), v18.3.0[2] Table 8.11.2.1.0-1 in 38.305, Use equipment (UE) positioning in NG-RAN (Release 18), v18.3.0**RAN1#119**AgreementFor the definition of sample-based measurement, for gNB/TRP measurement of an estimated channel response between a pair of UE and TRP, the starting time of the list of Nt consecutive samples is determined as follows.* + starting time = first detected path rounded down with timing granularity T.

Note: UE-side measurement is a separate discussionAgreementFor model performance monitoring of AI/ML positioning Case 1, support at least: * Option A. The target UE side performs monitoring metric calculation.
	+ The target UE may signal the monitoring outcome to the LMF.
	+ FFS: content of monitoring outcome
* FFS: Option B

AgreementFor Rel-19 AI/ML based positioning, for Case 3b, in addition to path-based measurement that is referring to the measurement in the existing specifications (up to Rel-18), additionally support the following enhancement to the measurement, * The measurement is composed of Nt' values of the estimated channel response in time domain. The Nt’ values are selected from a list of Nt consecutive channel response values, which have timing granularity T.
* The timing information for the Nt' values are reported with a timing granularity T, where T=2kxTc. k represents the timing reporting granularity factor. Tc is the basic time unit for NR.
	+ The associated measurement (e.g., power if reported) corresponds to the measurement for the reported Nt' values.
* The timing information is defined relative to a reference time, same as the path-based measurement.
* The Nt’ selected time domain channel measurement values are expected to be those with the highest power.
* The starting time of the list of Nt consecutive values is determined as: starting time = first detected path rounded down with timing granularity T.
* LMF can signal parameter values of Nt, Nt', k to gNB via NRPPa. Candidate set values:
	+ Nt'<=24. FFS: Nt' values.
	+ Nt = {32, 64, 128}
	+ FFS: k
	+ The gNB/TRP may use different Nt', Nt and/or k values other than the signalled parameter for measurement reporting. In this case, it’s up to LMF implementation to process the reported measurement
* FFS: whether transmit offset from gNB to LMF

Note: measurement by UE is a separate discussion.Note: the purpose of the time domain channel measurements, such as for Rel-19 AI/ML based positioning, is not specified AgreementFor AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:* Alternative 1. Info #7 is provided implicitly via associated ID.
	+ Associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 2. Info #7 can be provided either implicitly or explicitly by LMF. Note: no UE capability is introduced on whether info #7 is provided implicitly or explicitly, and the UE can request info #7 to be provided explicitly or implicitly.
	+ If provided implicitly, associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 3. Info #7 is **not** be provided from LMF to UE.
	+ If info #7 is not provided, UE may assume info #7 is consistent between training and inference.
* Alternative 4. Info #7 is provided explicitly from LMF to UE.

|  |  |
| --- | --- |
| 7 | Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

 |